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(58) Field of Search
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(54) An array of microlenses each assosciated with two pinholes

(57) A lens system consists of an array of microlenses 11 arranged in a single plane, each microlens being associated with first and second pinhole means 12, 13 to be associated respectively with a light source 15 and a detector 18. In use light from the light source 15 and associated pinhole means 12 passes through a microlens 11, is reflected from a surface 16 and passes back through either that microlens or an adjacent microlens and its associated pinhole means 13 to a detector 18.

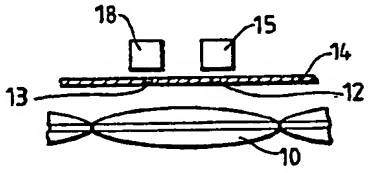

Fig.3.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

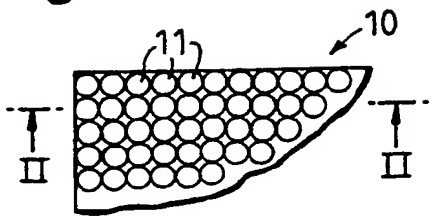


Fig.2.

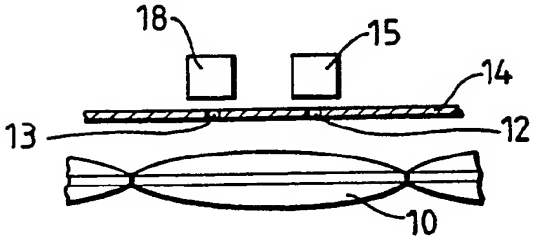


Fig.3.

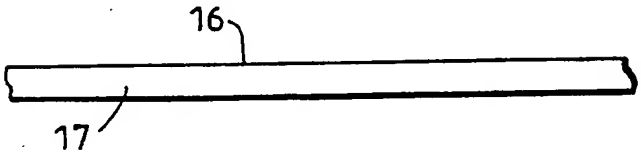
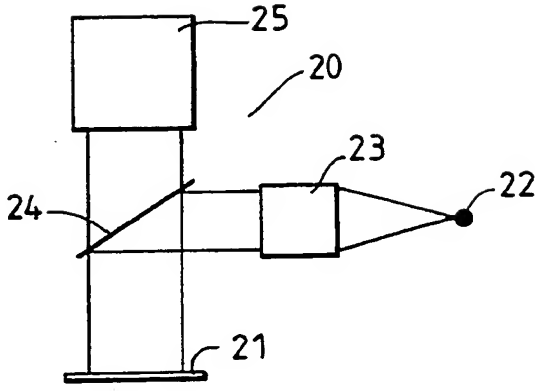


Fig.4.



Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
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Relevant Technical Fields

(i) UK Cl (Ed.M) G2J (J8X, JB7C14)

(ii) Int Cl (Ed.5) G02B

Search Examiner
MR C J ROSS

Date of completion of Search
13 JUNE 1994

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-
1-16

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A	EP 0518362 A1 (OMRON)	

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

14. A lens system as claimed in Claim 12 wherein the recording instrument is a combined photo-detector data processing array.

15. A confocal microscope including a lens system as claimed in any one of Claims 1 to 6.

16. A lens system substantially as herein described with reference to Figures 1 to 6 of the accompanying drawings.

Claims

What is claimed is:

1. A lens system including a plurality of microlenses arranged in a single plane, each microlens having associated therewith first pinhole means to be associated with a light source and second pinhole means to be associated with light originating from the light source which has passed through a microlens and then been reflected from a surface.

2. A lens system as claimed in Claim 1 wherein the first pinhole means is associated with the light source to provide a point light source.

3. A lens system as claimed in Claim 1 or in Claim 2 wherein the second pinhole means is associated with a detector to proved a point detector.

4. A lens system as claimed in any one of Claims 1 to 3 wherein light passing through each microlens return through that microlens after reflection.

5. A lens system as claimed in any one of Claims 1 to 3 wherein light passing through each microlens returns through an adjacent microlens after reflection.

6. A lens system as claimed in any one of Claims 1 to 5 wherein there are 50,000 to 100,000 microlenses.

7. A lens system as claimed in any one of Claims 1 to 6 in association with a light source.

8. A lens system as claimed in Claim 7 wherein the light source includes a light emitting diode (LED) for each microlens.

9. A lens system as claimed in Claim 7 wherein the light source includes an optical fibre for each microlens.

10. A lens system as claimed in Claim 7 wherein the light source includes a single source using collimating lenses and beam splitters.

11. A lens system as claimed in any one of Claims 1 to 6 formed in one unit with light sources and analysis equipment.

12. A lens system as claimed in any one of Claims 1 to 11 including a recording instrument.

13. A lens system as claimed in Claim 12 wherein the recording instrument is a charged couple device (CCD) camera.

The lens system 21 focuses light passing through an array of pinholes onto the surface 16 of sample 17 and reflected light passes back into the lens system 21, through the beam splitter 24 to a recording device 25 which may be a CCD camera. With this arrangement a single reading will give a the information on a complete section of the surface 16.

Two forms of optical arrangement are shown in Figures 5 and 6, in which light sources 15 and first pinholes 12 are combined as units, and detectors 18 and second pinholes 13 are combined as units. In figure 5 light from a source 15 passes through a microlens 11 and returns to a detector 18 through the same microlens 11. In Figure 6 light from a source 15 passes through a microlens 11 and returns to a detector 18 through an adjacent microlens 11.

Other forms of the invention will be readily apparent to those skilled in the art.

Many instruments other than confocal microscopes can use the lens array of the invention. For example an instrument containing its own light source and placeable directly on a surface could be constructed using the system. Such an instrument might contain its own analysis system in the form, for example, of a microcomputer.

drawings, of which:

Figure 1 is a plan view of part of a microlens array for use in the invention,

Figure 2 is an elevation, in section along line II-II of Figure 1, of the microlens array,

Figure 3 is an enlarged elevation of a single microlens from the array of Figures 1 and 2 forming part of a lens system according to the invention,

Figure 4 is an elevation of a confocal using the microlens system of the invention as a confocal microscope adaptor,

Figure 5 is an elevation, similar to that of Figure 3, showing three microlenses forming part of another lens system according to the inventions and using a first optical arrangement, and

Figure 6 is an elevation similar to that of Figure 5 showing the use of a second optical arrangement.

A microlens array 10 (Figures 1 and 2) contains a plurality of microlenses 11, each having the same numerical aperture and focal length. The total number of microlenses can be in the order of 50,000 to 100,000.

A lens system incorporating the array 10 has each microlens 11 (Figure 3) associated with a first pinhole 12 and with a second pinhole 13, shown as being formed in a single sheet 14 precisely located relative to the array 10.

In use, each microlens 11 is associated with a light source. Figure 3 shows a single light source 15 for each microlens, and this may be, for example, a light emitting diode or the tip of an optical fibre. Light from the source 15 is focussed through the pinhole 12 and through the microlens 11 onto a surface 16 of a sample 17. Light reflected from the surface 16 passes back through the microlens 11 and through the pinhole 13 and is collected by a light collector 18. The light collector 18 might be, for example, part of a CCD camera or the tip of an optical fibre.

One form of instrument, a confocal microscope 20, is shown in Figure 4. In this a lens system 21 according to the invention is positioned to replace the lens of a conventional microscope. Light from a light source 22 passes through a collimating lens 23 and is reflected from a beam splitter 24 to pass through the lens system 21.

and then been reflected from a surface.

The arrangement may be such that a light beam from a light source and associated pinhole means and its reflected beam both pass through the same microlens. Alternatively the beam and its reflected beam might pass through adjacent microlenses.

In one form of the invention the microlenses are associated with a combined first pinhole means and light source in the form of a point light source. Also the second pinhole means might be combined with a detector in the form of a point detector.

The microlenses must all have the same numerical aperture and focal length and a typical system will usually have more than 10,000, and preferably 50,000 to 100,000 microlenses.

The lens system might be associated with a light source in the form of a series of light emitting diodes (LEDs), there being one LED for each lens, or a single source providing individual point sources for the individual lenses by means of optical fibres, or a single source using collimating lenses.

The reflected light will normally be channelled to a recording instrument such as a charged couple device (CCD) camera and the information stored digitally in a computer.

The manufacture of arrays of microlenses of high numerical aperture is well known in the art, as is the manufacture of matched arrays of pinholes by, for example, photolithography.

In one form of the invention source and imaging pinholes, in the form of LED arrays, photo-detectors and analysis electronics are included on a single integrated device.

One form of instrument using the lens system is a confocal microscope adaptor with the lens system replacing the lens of a conventional microscope.

Another form of instrument, in which an integrated device would be especially appropriate, would be an optical device which could be placed directly on a surface of interest and which would provide a direct three dimensional topographic map of the surface. Such an instrument could, of course, also or alternatively be connected to recording or analysing equipment.

Some embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic

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OPTICAL LENSES

The present invention is concerned with optical lens systems for use, in particular, with apparatus for obtaining three dimensional surface texture information.

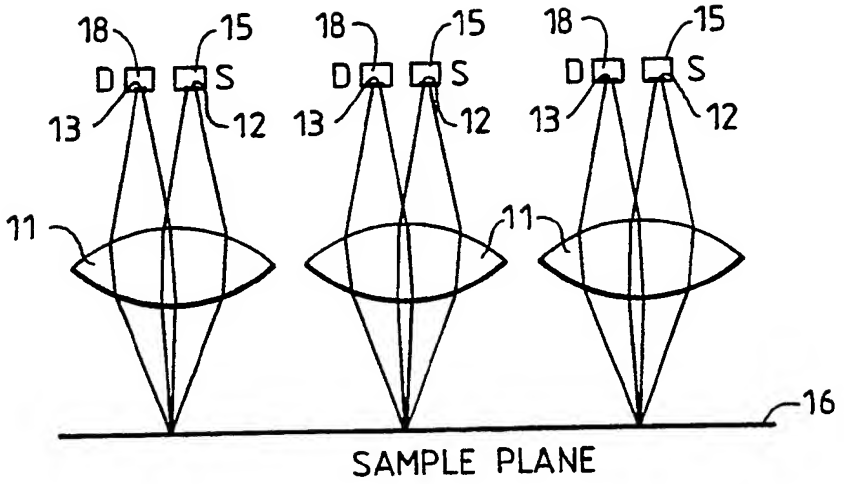
One form of obtaining three dimensional surface texture information is known as confocal microscopy. This is a non contact technique which is easy to use and which also provides a high resolution image of an area being investigated. A pinhole light source is used to illuminate a sample point, and the light returned is collected by a lens at a pinhole detector. The pinholes might be integral with or separate from the light source or the detector lens. With this arrangement light is returned only from points within a narrow zone above and below the focal plane of the microscope. Depending on the numerical aperture of the lens, the refractive index of the medium through which light is travelling, the size of the pinhole and the wavelength of the light, the depth of this zone might typically be 0.2 micrometers. An entire surface area is scanned using this technique. The procedure is repeated at a series of levels to provide three dimensional surface topographical information. The entire process is extremely time consuming.

A less time consuming form of confocal microscopy is based on a Tandem Scanning Microscope (TSM) and uses a spinning Nipkow disc. A Nipkow disc is a perforated disc, usually made of silicon, with a plurality of holes arranged in Archimedian spirals such that perforations lie in diametrically opposed pairs of illuminating and imaging pinholes as the disc spins. Many points of a surface are sampled simultaneously. Even with this technique the preparation of a three-dimensional map of surface texture can take up to one minute.

The present invention provides a novel optical lens system suitable for use in confocal microscopy.

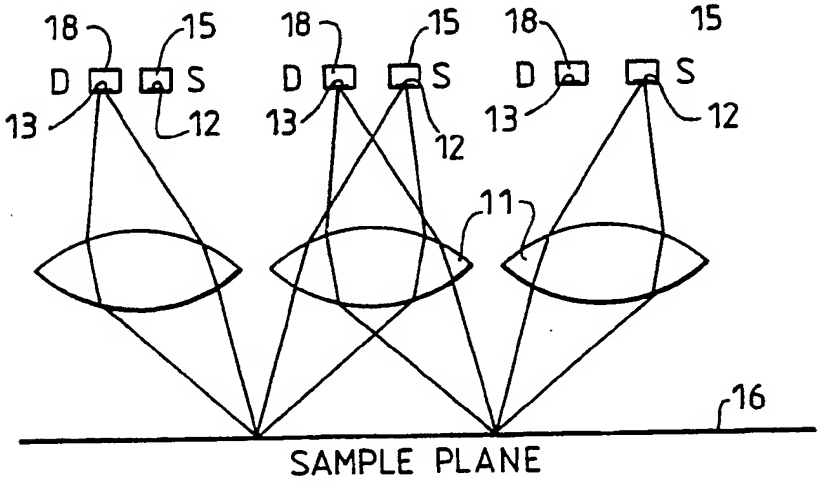
According to the present invention a lens system includes a plurality of microlenses arranged in a single plane, each microlens having associated therewith first pinhole means to be associated with a light source and second pinhole means to be associated with light originating from the light source which has passed through a microlens

Fig.5.



D IS POINT DETECTOR
S IS POINT SOURCE

Fig.6.



D IS POINT DETECTOR
S IS POINT DETECTOR